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BRUCE GS 'B' PREOPERATIONAL BIOLOGICAL STUDY YEAR IV 1982-83

Report No 83-507-K

H. Balesic
Biological Research Section
Chemical Research Department

ABSTRACT

Year IV pre-operational studies at Bruce GS 'B' were conducted to provide additional information on bottom substrates, ichthyoplankton and winter fish populations. Combined pre-operational substrate data from Douglas Pt to MacRae Pt indicated that exposed bedrock predominated at 1-5 m depths, while boulder-cobble substrates predominated at 6 to 12 m depths. The ichthyoplankton at 1 m depth in May 1982 was dominated by rainbow smelt (74%) and burbot (25%). Gill net catches in January and February, 1983 were dominated by burbot (34%), white sucker (28%), longnose sucker (17%) and round whitefish (9%). Most round whitefish were caught in shallow (5 m) sets, while most suckers and burbot were caught in deep (12 m) sets.

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To Dr. W.R. Effer
Manager
Environmental Studies & Assessments Dept
Design and Development Division

BRUCE GS 'B' PREOPERATIONAL BIOLOGICAL STUDY
YEAR IV 1982-83

H. Balesic

1.0 INTRODUCTION

This report presents results of year IV preoperational aquatic studies conducted at the Bruce GS 'B' site from April, 1982 to February, 1983. These studies were requested by Environmental Studies and Assessments, Design and Development Division to provide detailed information on the aquatic environment in the vicinity of Bruce GS 'B', against which environmental information obtained during later post operational studies could be compared.

The normal three preoperational biological studies were conducted at the site in the years 1979, 1980 and 1981. At the conclusion of this sampling program it was felt that the preoperational data base was incomplete in several areas, especially winter fish populations and, to a lesser extent, early spring ichthyoplankton and bottom substrates. Due to delays in commissioning of Bruce GS 'B', it was possible to address these deficiencies by adding a fourth preoperational year of sampling.

At the start of sampling in May, 1982 shoreline modifications (armour stone, discharge dykes) and intake excavation had been completed. The only major construction activity occurring during the study period was the installation of the intake structure during June - September, 1982. Since this construction started after the completion of ichthyoplankton sampling and finished well before the start of winter fishing, it had no direct relevance to results of fish studies, but it may have had some influence on the nearshore distribution of fine substrates.

2.0 STUDY AREA AND METHODS

2.1 Study Area

The Bruce GS 'B' site is located in the southern portion of the Bruce Nuclear Power Development (BNPD). The study area extends from Douglas Point south to McRae Point (Figure 2-1). Sampling in 1982 was conducted to the 12 m contour, as has been the case for all previous preoperational studies, with the exception of plankton and acoustic grids.

2.2 Substrate

Photographs of substrate were obtained by divers at six 1 m depth contour locations to complement data obtained in 1980 and 1981 (Figure 2-1). Rough conditions and poor visibility during the two scheduled visits to the site prevented the acquisition of further data between transects, particularly at depths beyond 1 m, which would have increased the resolution available for substrate mapping.

Photographs were taken in three replicate groups of three at each location. The camera was supported at a standard distance above a 1 m^2 frame resting on the substrate. The slide offering the best resolution was selected from each replicate group, and measurements of substrate particle size and per cent contribution of substrates made from a 20% projected portion of the slide (0.175 m^2).

2.3 Ichthyoplankton

Ichthyoplankton was collected on seven dates from April 29 to May 27. Sampling was conducted after dusk at approximately the 1 m contour on eight transects (Figure 2-1). Douglas Point in the north and Inverhuron Bay in the south were added to the six transects sampled in 1981. Two 0.5 m conical nets with 363 µm mesh were towed in tandem for five minutes. General Oceanics current meters mounted at the mouth of each net were used to determine sampling volume. Mean estimated sampling volumes among transects did not vary appreciably, ranging from 32-37 m^3/tow (Appendix 3). An overall mean sampling volume of 35.7 m^3/tow was used in computatations of ichthyoplankton density. Samples were preserved in 10% formalin and sorted and identified in the laboratory. Total lengths of up to 10 larval fish of each species were measured per net.

2.4 Winter Fish Populations

Adult and juvenile fish were sampled using experimental gill nets set at the 5 and 12 m depths on six transects from Douglas

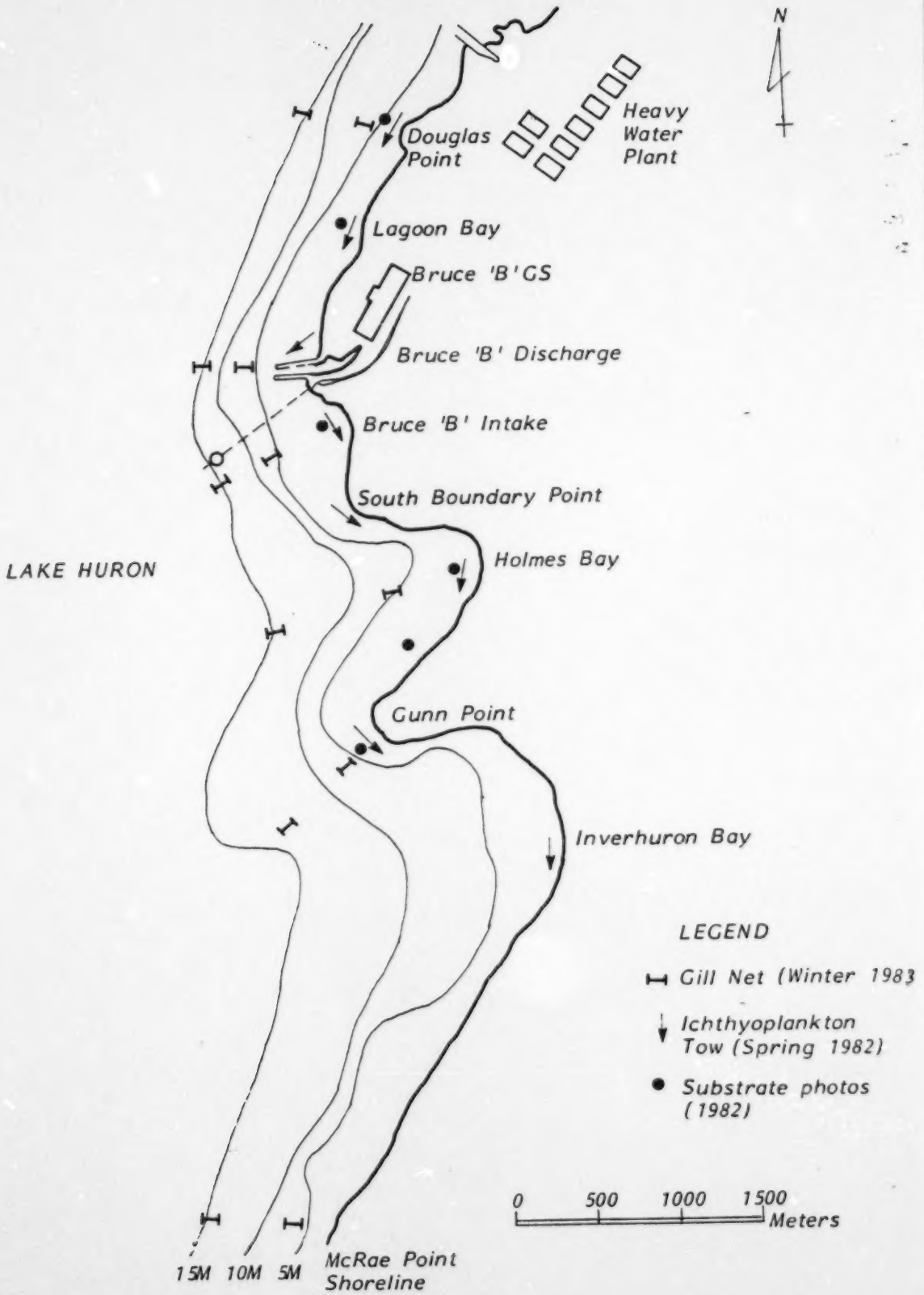

FIGURE 2-1

SAMPLING LOCATIONS - BRUCE GS 'B', 1982-83

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Point to McRae Point (Figure 2-1). These locations duplicated gill netting locations during the ice-free period in previous preoperational survey years, except that the inshore nets were set at 5 instead of 3 m to avoid hazardous inshore ice conditions.

Experimental gill nets consisted of eight 20 m panels with mesh from 2.5 cm (1") to 12.5 cm (5"). According to practice established in previous surveys, they were fished perpendicular to shore, with the inshore end (the smallest mesh) fished at the 5 or 12 m contour. Nets were fished for two consecutive 24 h periods in each of January and February. The late start of sampling in January (Jan 29) followed two earlier attempts to initiate sampling which were unsuccessful due to inclement weather.

3.0 RESULTS AND DISCUSSION

3.1 Substrate

Information taken from substrate photographs in 1982 was combined with that from other years to give a picture of substrates at the site in the greatest possible detail. The data was summarized in Appendix 1, and maps giving a composite of the four years of sampling prepared (Figures 3-1A and B). Details of replicate observations for 1982 (1 m contour) are given in Appendix 2.

Shoreline Substrates: The shoreline refers to the splash zone, which is normally exposed, but is subject to wave action whenever strong onshore winds occur. The exact location of the splash zone changes with changing water levels so that the area sampled could shift onshore as water levels rise. In addition, wave activity can result in periodic deposition or removal of smaller substrates. These factors, which have not been documented, increase the likelihood of changes in the characteristics of shoreline substrates sampled from year to year.

From Lagoon Bay to the Bruce GS 'B' intake the shoreline has been modified by the installation of armour stone (Figure 3-1A). Depending on water levels, a splash zone of natural substrates may occur at the base of the armour stone. The shoreline from Douglas Point to Holmes Bay was largely dominated by boulder-cobble, with some areas of exposed bedrock (south of Lagoon Bay) and pebble-gravel (between the Bruce GS 'B' discharge and intake transects).

Gravel-pebble predominated from Holmes Bay to Gunn Point while sandy beaches were present from Gunn Point to Inverhuron Bay.

The shoreline south of Inverhuron Bay, which had widely spaced sampling points, consisted primarily of exposed bedrock and boulder-cobble.

Predominant Substrates - 1 to 12 m: Exposed bedrock predominated at all depths in the north end of the study area (Figure 3-1A). At shallow-to-moderate depths (1-5 m) bedrock predominated over much of the study area. Exceptions were found in the immediate vicinity of Bruce GS 'B', where these depths were dominated by boulder-cobble, and Holmes Bay, where bottom substrates ranged primarily from boulder to pepple. In 1979 substrates at Holmes Bay were largely overlain by sand (3-4 m) and then silt (5-7 m) but in 1980 they were exposed (Ontario Hydro Research Division Report No 83-182-K and No 82-205-K). At greater depths (8-12 m) most of the area south of Douglas Point was dominated by boulder-cobble. Exceptions consisted of an area of gravel-pebble off Lagoon Bay in the north, and an area of sand off Inverhuron Bay in the south.

Distribution of Principal Substrate Categories, 1 to 12 m:
Exposed Bedrock: The distribution of exposed bedrock at the site is shown in Figure 3-1B. Exposure of bedrock ranged from 0 to 100%. In intermediate cases, the distribution of the overlying substrates tended to be very patchy, so that there was a great deal of variation among replicate photographs taken in similar locations. Such substrates cannot, therefore be described with a high degree of precision. Bottoms with a higher proportion of exposed bedrock (76 to 100%) were restricted to shallow and intermediate depths off Douglas Pt, Gunn Pt and Inverhuron Bay. However, a substantial proportion of exposed bedrock (26 to 75%) was found at greater depths off Douglas Pt, and at shallow to intermediate depths over most of the remaining study area.

The occurrence of a large proportion of exposed bedrock is significant biologically, in that, with the exception of ledges and fissures, it affords no protection for benthic fish or invertebrates from turbulent currents or predators. However, at shallow depths it may be readily colonized by periphyton, which in turn provides a suitable microhabitat for benthic invertibrates, particularly the oligochaetes (Ontario Hydro Research Division Report No 82-107-K).

Boulder - Cobble: This substrate category tended to be most prevalent from the 7 to 12 m depth contours. High proportions of boulder-cobble (76 to 100%) were found off the Bruce GS 'B' intake and McRae Pt, and an area of greater than 50% boulder-cobble stretched from the Bruce GS 'B' discharge past Gunn Pt. Inshore areas consisting of more than 75% boulder-cobble were found off South Boundary Pt, and to the north and south of Holmes Bay.

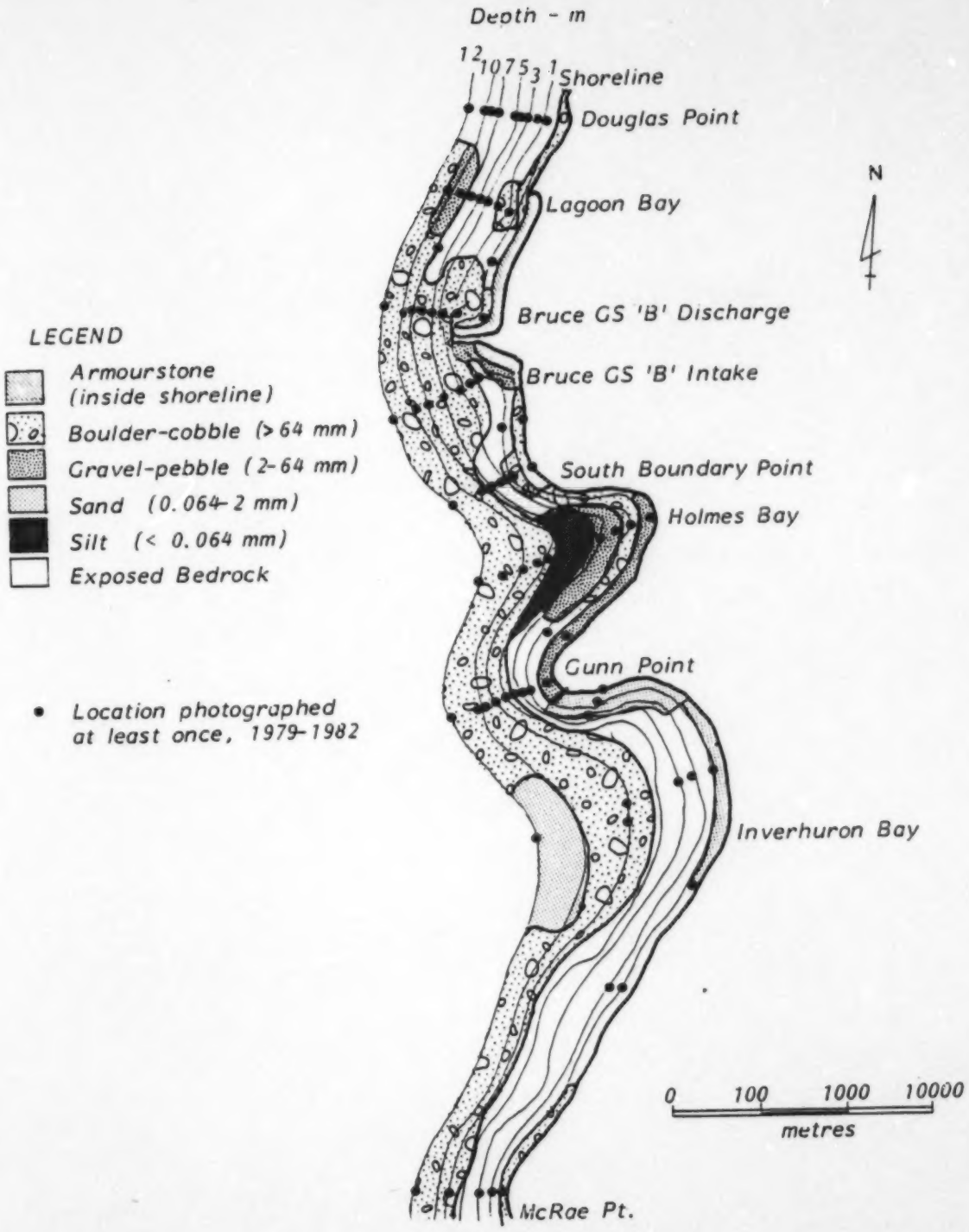

FIGURE 3-1

SUBSTRATES AT BRUCE GS'B' (COMPOSITE, 1979 - 1982)
(A) PREDOMINANT SUBSTRATES

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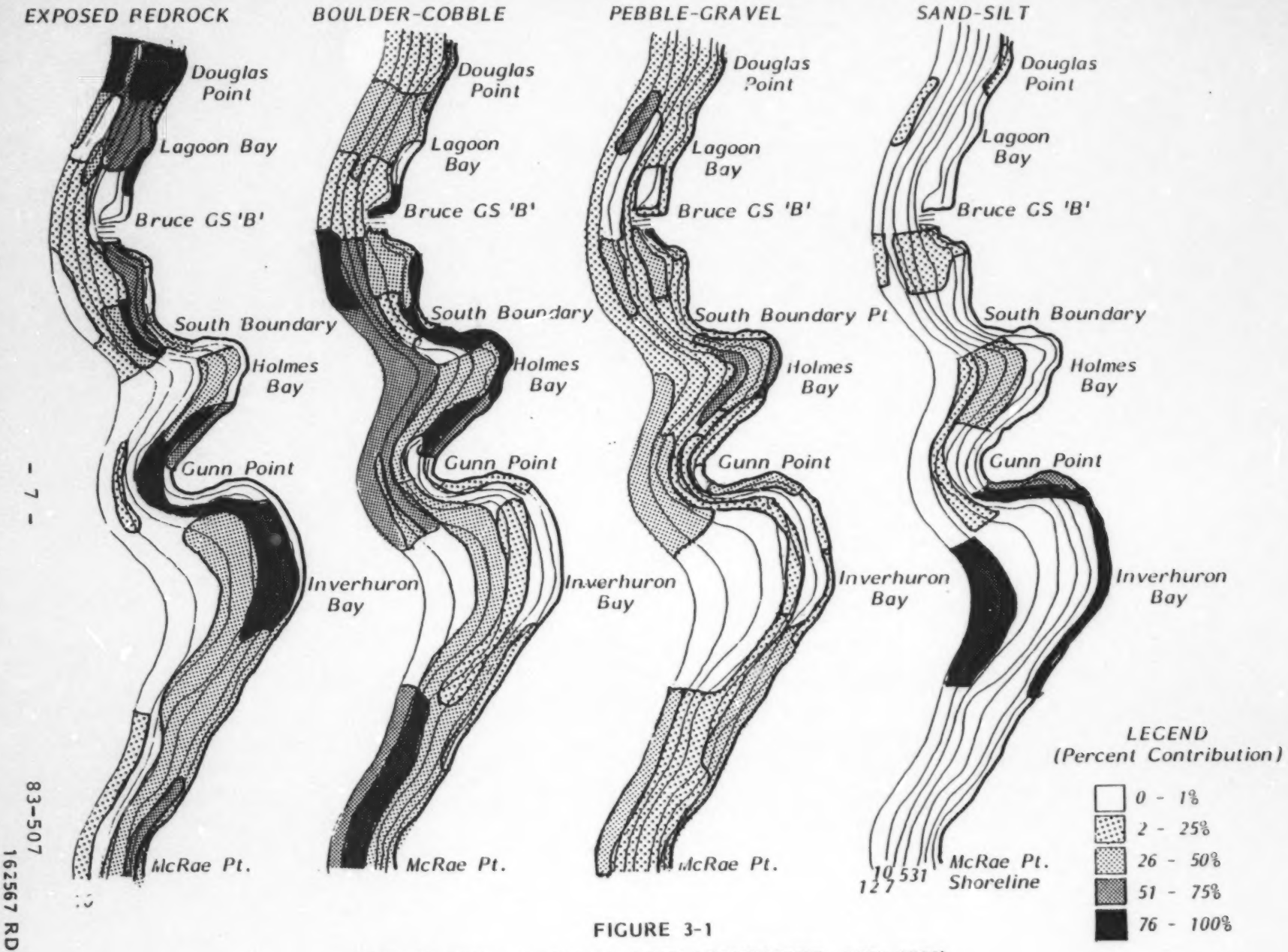

FIGURE 3-1

SUBSTRATES AT BRUCE GS 'B' (COMPOSITE, 1979-1982)
(B) DISTRIBUTION OF MAJOR SUBSTRATE CATEGORIES

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Boulder-cobble affords the greatest amount of cover for benthic fish species such as sculpins.

Pebble Gravel: Although much of the site had at least some pebble-gravel substrates, they did not cover a very high proportion of the bottom at any location. The only areas with more than 50% pebble-gravel were found at 3 to 5 m in Holmes Bay and at 7 to 10 m off Lagoon Bay. The most extensive areas with moderate amounts of pebble-gravel (26 to 50%) appeared to occur within Holmes Bay and off Gunn Pt. Although it appeared that inshore and offshore areas south of Inverhuron Bay had moderate amounts of pebble-gravel, this region suffers from a lack of detail in sampling points.

The distribution of pebble-gravel substrate is of particular interest, in that such substrates are preferred for spawning by a number of fish species, including suckers, centrarchids and salmonids (Scott and Crossman, 1973).

Sand and Silt: The distribution of these fine substrates (Figure 3-1b) was rather limited and varied from year to year. Substantial amounts of sand and silt were found from 2 to 7 m depths in Holmes Bay (in 1979 only), while the substrate off Inverhuron Bay in 1980 was found to be almost entirely overlain by sand. The amounts of sand and silt found in the northern portion of the site were small. The extent to which the occurrence of silt cover in 1979 was related to construction activities is unknown.

Although it was evident that at any one time sands covered a relatively small portion of the site, it appeared that they were subject to considerable shifting due to currents, and thus would provide an inhospitable environment for benthic organisms. Sand was found to be preferred by round whitefish larvae in the laboratory (Ontario Hydro Research Division Report No 83-57-K) but the extent to which it is utilized by these larvae in the field is unknown. Accumulations of silt would substantially affect the composition of the zoobenthic community, and prevent successful incubation of demersal fish eggs through creation of an anoxic microhabitat, particularly in the interstices of pebble - gravel substrates.

3.2 Ichthyoplankton

Inshore (1 m) tows conducted from April 29 to May 27 yielded 26 fish eggs and 2802 larval fish. All eggs and 74% of larvae were rainbow smelt (Table 3-1, Appendix 3). Of four other species taken, only burbot (25%) occurred in significant numbers.

TABLE 3-1

SPECIES COMPOSITION OF ICHTHYOPLANKTON
TAKEN IN INSHORE TOWS, APRIL-MAY 1982

Species	Number Caught	% of Total Caught
Rainbow Smelt	2071	73.9
Burbot	718	25.6
White Sucker	6	0.2
Deepwater Sculpin	6	0.2
Longnose Sucker	1	<0.1
Total Larvae	2802	
Smelt eggs	26	

This sampling program was timed to coincide with the emergence of larvae spawned in fall or early spring. Dominance of the spring ichthyoplankton at the site by rainbow smelt (early spring spawners; Scott and Crossman, 1973) is consistent with results of previous years (1978-81). Burbot, which spawn in late winter - early spring, also contributed a substantial portion of the ichthyoplankton in at least one previous year (1980). However, neither round whitefish (fall spawners) nor yellow perch (early spring spawners) were collected, although both species had been taken in small numbers in 1979 and 1981 (Ontario Hydro Research Division Report No 83-451-K). During the course of sampling ambient surface temperatures remained below 10°C (Appendix 3). This may explain the absence of yellow perch, since larvae of this species may not become pelagic until surface water temperatures reach 13°C (Faber, 1967).

Temporal and Spatial Distribution

Densities of the two dominant species are shown by week and transect in Figure 3-2. On the first two sampling dates (April 29, May 5) only rainbow smelt eggs were taken. Larvae of both rainbow smelt and burbot were first taken on May 14, and were most abundant in the last sampling week.

Rainbow Smelt: Mean densities of rainbow smelt eggs were highest on April 29 - May 5 (29 eggs/1000 m^3). Since the eggs are normally demersal and adhesive (Scott and Crossman, 1973), these collections were indicative of the presence of greater densities of developing eggs on nearby substrates. Once the larvae appeared, eggs became rare in the samples. Mean densi-

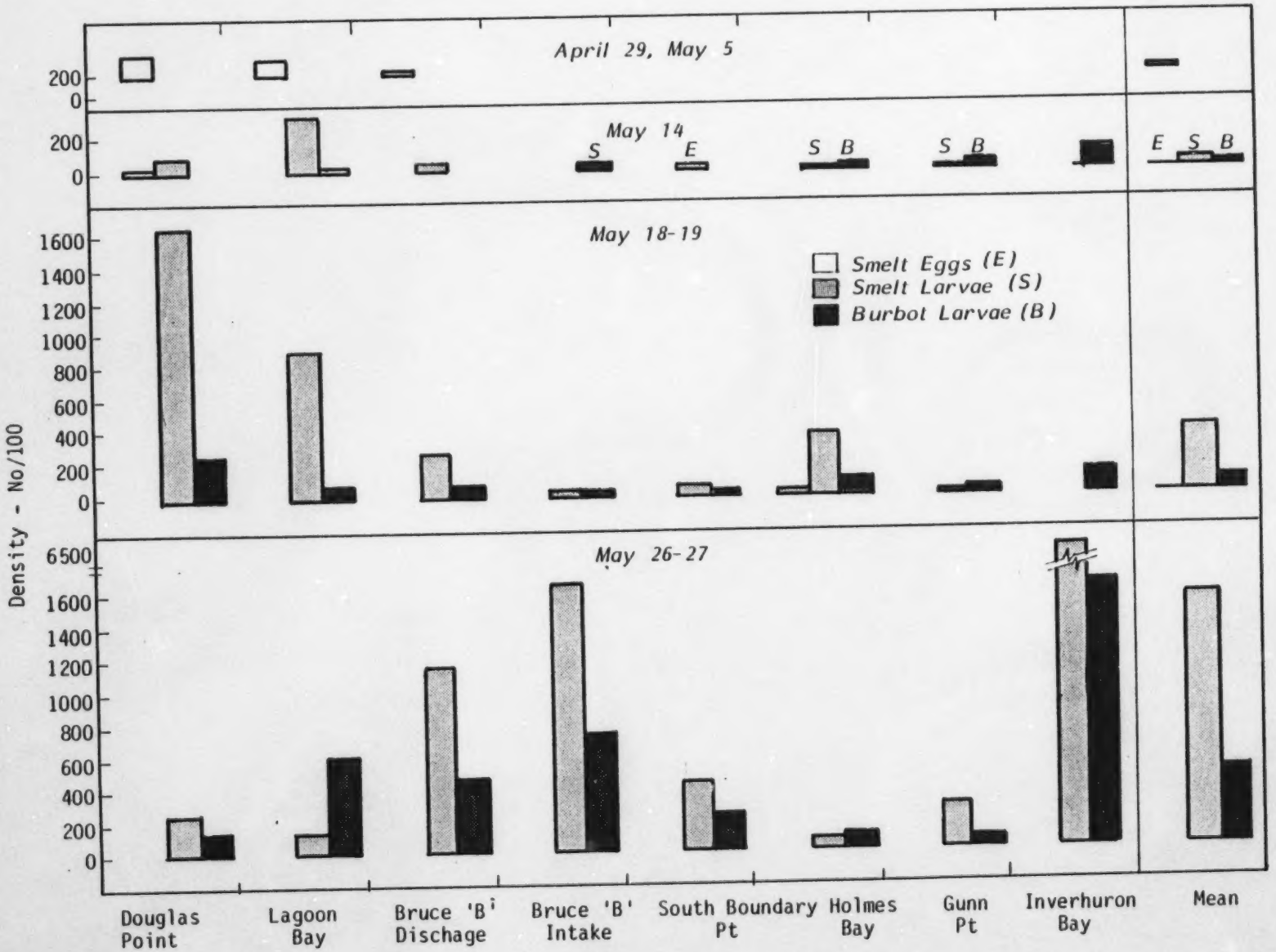

FIGURE 3-2

SPATIAL AND TEMPORAL DISTRIBUTION OF PRINCIPAL ICHTHYOPLANKTON

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ties of smelt larvae increased in successive weeks, reaching a peak of 1600/1000 m^3 on May 26-27. The peak mean density was somewhat lower than peak mean densities observed in 1981 (3300/1000 m^3) but similar to peak mean densities observed in 1980 (1920/1000 m^3).

From May 14 to 26-27 there was a slight increase in the mean length of smelt larvae from 5.3 mm to 6.1 mm. Only recently hatched larvae were present nearshore, as none of the larvae exceeded 7 mm (Appendix 3). The incubation period of smelt eggs at 6°C is approximately 40 days (Ontario Hydro Research Division Report 78-343-K). If it can be assumed that the larvae caught were largely incubated under ambient conditions, then smelt spawning could have occurred in mid or late April.

Virtually all smelt eggs and most larvae on May 14 and May 18-19 were found at Douglas Point and Lagoon Bay (1600 and 900 larvae/1000 m^3 on May 18-19; Figure 3-2), which were the northernmost transects of the study area. In the last sampling week, the distribution of smelt larvae shifted southward, with highest densities found on Bruce GS 'B' intake (1600/1000 m^3) and Inverhuron Bay (6500/1000 m^3) transects. These data suggested the possibility that smelt spawning was concentrated along the northernmost shoreline of the site and that subsequently alongshore currents resulted in passive displacement of larvae to the south. It is not apparent that substrates or topography in the northern part of the site were more suitable for smelt spawning than those from Holmes Bay southwards. Gravel, which is a preferred substrate for smelt spawning (Scott and Crossman, 1973), occurs throughout the site, but is most predominant in the area of Holmes Bay and Gunn Pt (Figure 3-1B). It is possible that the discharges of Douglas Pt GS, as well as others north of the study area could have been used for smelt spawning, but it cannot be determined what proportion, if any, of the larvae caught were spawned and incubated in thermal discharges.

Concentration of larvae in Inverhuron Bay in particular could have resulted from current patterns similar to those which favoured the deposition of sand along that shoreline (1980 data). In 1982 currents were monitored 3 km off Bruce GS 'A' at 8 m depth (Hydraulic Studies and Development current meter CMA 14; preliminary data). Although considerably removed from the inshore sampling locations, this meter should have reflected the prevailing direction of alongshore currents. Hourly current readings were initially low in velocity and variable in direction. However, during the period from May 20 to 26 hourly current readings of 5 cm/s or greater were recorded 2.5 times as often in the south-west quadrant (180 - 270°; 20 of 35 readings) as in the north-east quadrant (360 - 90°; 8 readings). This indicates prevailing southerly alongshore flows between the last two sampling periods and is consistent with the suggestion of passive southerly displacement of smelt larvae.

Burbot: Mean densities of burbot larvae increased from 40 to 500/1000 m^3 between May 14 and May 26-27. Peak mean densities of burbot larvae were at least twice as high as those observed in any previous year (230/1000 m^3 in 1980). There was no appreciable change in the size of burbot larvae over time with weekly mean length ranging from 4.0 to 4.1 mm (Appendix 3), suggesting continual recruitment of recently hatched larvae.

There was no obvious trend in the distribution of burbot larvae during May 14 and May 18-19. On May 26-27, when densities were highest, their distribution approximated that of rainbow smelt. As with smelt, concentration of larvae in Inverhuron Bay was apparent at that time.

3.3 Winter Fish Populations

Community Composition

A total of 335 fish of 12 species were taken by gill netting in January and February, 1983. Burbot was the most commonly caught species (34%), followed by white and longnose suckers and round whitefish (Table 3-2; Appendix 4). There was little difference in species composition in the two months, which was not unexpected, since (due to weather), the actual sampling dates were only separated by 11 days and conditions were comparable.

The gill net catches made in this study in mid-winter were quite distinct from those made at Bruce GS 'B' in early spring (March-April, 1981; Ontario Hydro Research Division Report No 82-205-K), where gizzard shad and alewife predominated, with burbot making up 2% of the catch. They resembled more closely the species composition on December 15, 1981 (1981 round whitefish spawning study; Ontario Hydro Research Division Report No 83-451-K), when burbot, white sucker and round whitefish dominated the catch.

Spatial Distribution and Abundance

The distribution of the catch-per-unit effort of the four principal species is shown by depth and transect in Figure 3-3.

Catches of white sucker, burbot and longnose sucker were consistently greater at the 12 m depth than the 5 m depth, while the opposite was true for round whitefish. Mean catches of burbot and suckers at the 12 m depth (3.5 burbot, 3 white sucker and 1.5 longnose sucker) were two to three times higher than the catches at 5 m. In contrast, the mean catch of round whitefish at 5 m (1/net) was 10 times greater than the catch at 12 m. The depth distribution of these four species was similar to that observed in late fall, 1981.

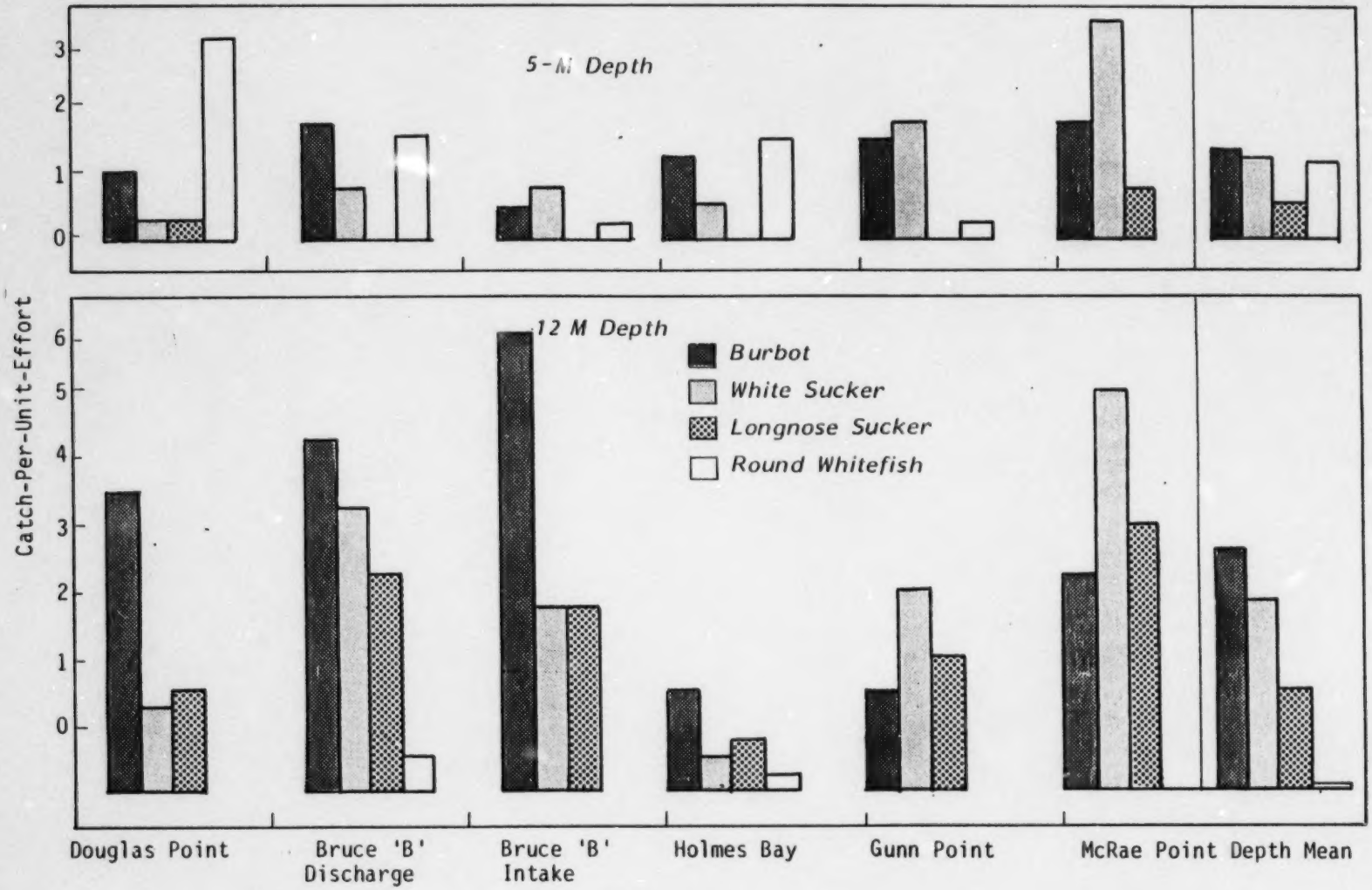

FIGURE 3-3

SPATIAL DISTRIBUTION OF GILL NET CATCH-PER-UNIT-EFFORT
WINTER, 1983

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TABLE 3-2

FISH SPECIES COMPOSITION OF GILL NET CATCH, WINTER 1983

Species	January 28,29		February 9,10		Total	
	No Caught	%	No Caught	%	No Caught	%
Burbot	34	29.0	82	37.6	116	34.6
White Sucker	37	31.6	59	27.1	96	28.7
Longnose Sucker	25	21.4	33	15.1	58	17.3
Round Whitefish	5	4.3	25	11.5	30	9.0
Lake Chub	8	6.8	10	4.6	18	5.4
Gizzard Shad	2	1.7	4	1.8	6	1.8
Spottail Shiner	3	2.5	1	0.4	4	1.2
Yellow Perch	1	0.8	2	0.9	3	0.9
Rainbow Smelt			1	0.4	1	0.3
Rainbow Trout	1	0.8			1	0.3
Walleye			1	0.4	1	0.3
Sea Lamprey	1	0.8			1	0.3
	117		218		335	

Burbot and the two sucker species were caught on all six transects, while round whitefish were not taken at McRae Point, but were present on the remaining transects. Both burbot and round whitefish were more commonly caught in the northern half of the study area. Maximum catches of burbot (6 fish/net) were made off the Bruce GS 'B' intake, 12 m depth. The distribution of suckers did not suggest clear along shore trends. However, both species were most abundant off McRae Pt, where highest catches in inshore and offshore nets were obtained. No ecological explanation can be offered for the observed spatial distributions of suckers and burbot.

Nuclear generation hourly records of Douglas Pt intake temperature suggested an intermittent influence of the discharge plume at 5 m depth on the Douglas Pt transect. Maximum intake temperatures during the time nets were set reached 2-3.5°C on the four sampling dates. Since a substantial catch of round whitefish was made on only one of these dates (12 on February 8), there is insufficient evidence to suggest attraction of round whitefish to the discharge plume. Although round whitefish were previously reported to be an important component of the fish catch at the Douglas Pt Discharge in fall (1975 Bruce GS 'A' study; Ontario Hydro Research Division Report 76-343-K), the

number of fish caught was small - only 21 round whitefish were taken in the entire 1975 gill netting program. In the November-December 1981 round whitefish spawning study (1981 Bruce GS 'B' study; Ontario Hydro Research Report 83-451-K) catches of round whitefish did not appear to be related to temperature, and catches at Douglas Pt were intermediate in comparison to other areas.

No statistical analyses were attempted due to the small total number of fish caught and the high degree of variability among individual replicates (Appendix 4).

4.0 SUMMARY

Substrates

Substrates from the shoreline to a depth of 12 m were described from photographic data taken in 1979-82. The shoreline, or splash zone, ranged from exposed bedrock to sand, with boulder-cobble substrates predominant. At 1 to 5 m depths exposed bedrock predominated over most of the study area, while beyond 5 m boulder-cobble was most often predominant. Moderate amounts of pebble-gravel were spread throughout the study area. Significant amounts of sand and silt cover were restricted to Holmes Bay (3 to 7 m) and Inverhuron Bay (10 to 12 m).

Ichthyoplankton

From April 29 to May 27, 1982, 2802 larval fish and 26 fish eggs were collected. All eggs were rainbow smelt and larvae were predominately rainbow smelt (74%) and burbot (25%). The fall-spawning round whitefish and early spring-spawning yellow perch were absent from the catch.

Rainbow smelt and burbot larvae both peaked in abundance at the end of the sampling program (May 26-27), with smelt reaching a mean density 1600 larvae/1000 m^3 and burbot 500 larvae/1000 m^3. Until May 19 both rainbow smelt eggs and larvae were taken predominately in the northern part of the site, while burbot larvae were distributed throughout the site. On May 26-27 both smelt and burbot appeared to be concentrated in Inverhuron Bay. This was probably due to southward displacement of larvae by currents.

Winter Fish Populations

Gill netting at 5 m and 12 m depths in January and February, 1983 produced a total of 335 fish. Principal species were Burbot (34%), white sucker (28%), longnose sucker (17%) and round whitefish (9%). Nets set at the 12 m depth produced the

greatest mean catches of burbot (3.5/net), white sucker (3/net) and longnose sucker (1.5/net), while nets set at the 5 m depth yielded the greatest mean catches of round whitefish (1/net). The greatest catch of round whitefish was made off Douglas Pt.

Approved:

D. Harrison
Manager
Chemical Research Dept

HB:ljh/rdm

Submitted:

H. Balesic
Biologist - Fish Behaviour
Biological Research Section

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APPENDIX 1

SUMMARY OF SUBSTRATE COMPOSITION AT BRUCE GS B

1979 - 1982 PHOTOGRAPHIC OBSERVATIONS

TRANSECT	DEPTH	MEAN % COMPOSITION							
		1979		1980		1981		1982	
		No Obs.	% Comp.	No. Obs.	% Comp.	No OBs.	% Comp	No OBs.	% Comp.
Between Douglas Point and BHWP	Shoreline			3	C 11 P 60 G 29				
Douglas Point	Shoreline	1	C 68 P 22 G 10	3	Bl 15 C 57 P 12 G 9 S 7				
	1M	1	Br 100					3	Br 52 Bl 1 C 18 P 22 G 5 Sa/Si 2
	2M	1	Br 100						
	3M	2	Br 88 Bl 10 P 2	3	Br 96 C 2 C 2				
	4M	2	Br 100						
	5M	4	Br 78 C 18 P 4						
	7M	3	Br 67 Bl 8 C 16 P 7 G 2	3	Br 77 C 13 P 10				

Br - Bedrock Bl - Boulder C - Cobble P - Pebble G - Gravel Sa - Sand Sl - Silt

>256 mm 64-256 mm 8-64 mm 2-8 mm .063-2 mm .038-.063 mm

Appendix 1 con't

MEAN % COMPOSITION									
TRANSECT	DEPTH	1979		1980		1981		1982	
		No Obs.	% Comp.	No. Obs.	% Comp.	No OBs.	% Comp	No OBs.	% Comp.
Douglas Point	9M	1	Br 100						
	10M	1	Br 52 Bl 8 C 20 P 20						
	12M	1	Br 74 C 10 P 16	3	Br 98 C 1 P 1				
Between Douglas Pt. and Lagoon Bay	Shoreline			3	Br 33 C 60 P 7				
Lagoon Bay	Shoreline	1	Br 96 P 4	3	Bl 23 C 39 P 38				
	1M							3	Br 28 Bl 16 C 36 P 17 G 3
	2M	1	Br 100						
	3M	3	Br 70 C 16 P 13 C 1	3	Br 35 Bl 22 C 36 P 6 G 1				

Br - Bedrock Bl - Boulder C - Cobble P - Pebble G - Gravel Sa - Sand Sl - Silt

Appendix 1 con't

TRANSECT	DEPTH	MEAN % COMPOSITION							
		1979		1980		1981		1982	
		No Obs.	% Comp.	No. Obs.	% Comp.	No OBs.	% Comp	No OBs.	% Comp.
	5M	1	Br 100						
Lagoon Bay	7M	1	Bl 40 C 40 P 18 G 2	3	Br 69 Bl 7 C 24				
	9M	1	C 44 P 47 G 9						
	10	1	C 46 P 53 G 1						
	12M	1	C 62 P 30 G 8	3	Br 31 C 49 P 15 G 2 Sa 3				
Between Lagoon Bay and Br. 'B' Discharge	Shoreline			3	Br 100				
	7M					3	Br 67 Bl 12 C 20 P 1		

Br - Bedrock Bl - Boulder C - Cobble P - Pebble G - Gravel Sa - Sand Sl - Silt

Appendix 1 con't

TRANSECT	DEPTH	MEAN % COMPOSITION							
		1979		1980		1981		1982	
		No Obs.	% Comp.	No. Obs.	% Comp.	No OBs.	% Comp	No OBs.	% Comp.
Br. 'B' Discharge	Shoreline	1	C 63 P 36 G 1	3	Bl 100				
	3M	1	Bl 100	3	Bl 96 C 4				
	5M	1	C 87 P 13			3	Br 33 Bl 58 C 9		
	6M	1	Br 100						
	7M	1	Bl 89 C 5 P 5 G 1	3	Br 16 Bl 16 C 44 P 19 G 5				
	12	1	Br 5 C 90 P 4 G 1	3	Br 33 Bl 33 C 22 P 10 G 2				
Between Br. 'B' Discharge and Intake	Shoreline			3	C 15 P 68 G 17				
Bruce 'B' Intake	Shoreline	2	Br 40 C 21 P 28 G 8 Sa 3	3	Br 22 C 39 P 26 G 13				

Br - Bedrock Bl - Boulder C - Cobble P - Pebble G - Gravel Sa - Sand Sl - Silt

Appendix 1 con't

TRANSECT	DEPTH	MEAN % COMPOSITION							
		1979		1980		1981		1982	
		No Obs.	% Comp.	No. Obs.	% Comp.	No OBs.	% Comp	No OBs.	% Comp.
Bruce 'B' Intake	1M							3	Br 60 Bl 16 C 17 P 5 G 1 Sa/Sl 1
	2M	1	C 36 P 56 G 8						
	3M	1	C 50 P 34 G 10 Sa 6	3	Br 27 C 49 P 14 G 10				
	5M	1	Bl 82 C 9 P 2 G 7						
	7M	1	C 54 P 40 G 6	3	Br 5 Bl 54 C 19 P 16 G 4 S 2				
	10M	1	Bl 73 C 24 P 2 G 1						

Br - Bedrock Bl - Boulder C - Cobble P - Pebble G - Gravel Sa - Sand Sl - Silt

Appendix 1 con't

TRANSECT	DEPTH	MEAN % COMPOSITION							
		1979		1980		1981		1982	
		No Obs.	% Comp.	No. Obs.	% Comp.	No OBs.	% Comp	No OBs.	% Comp.
Bruce 'B' Intake	12M	1	Bl 83 C 8 P 8 G 1	3	Bl 31 C 47 P 17 G 3 Sa 2				
Between Intake and S. Boundary Pt.	Shoreline			3	Bl 37 C 60 P 3				
	1M					3	Br 60 C 37 P 3		
S. Boundary Pt.	Shoreline	1	Br 100	3	C 44 P 35 G 21				
	1M					3	Br 83 C 8 P 9	3	Bl 63 C 30 P 6 G 1
	2M	1	Br 69 C 22 P 8 G 1						
	3M	1	Br 100	3	Br 75 C 18 P 5 G 1 Sa 1				

Br - Bedrock Bl - Boulder C - Cobble P - Pebble G - Gravel Sa - Sand Sl - Silt

Appendix 1 con't

MEAN % COMPOSITION												
TRANSECT	DEPTH	1979			1980			1981			1982		
		No Obs.		% Comp.	No. Obs.		% Comp.	No OBs.		% Comp	No OBs.		% Comp.
S. Boundary Pt.	5M	1	Br	96									
			P	4									
	7M	1	Bl	67	3	Br	63						
			C	9		Bl	10						
			P	24		C	22						
						P	3						
						G	2						
	12M	1	Bl	61	3	Br	18						
			C	30		Bl	26						
			P	9		C	25						
						P	24						
						G	5						
						Sa	2						
Between S. Boundary Pt. and Holmes Bay	Shoreline				3	Bl	63						
						C	21						
						P	16						
	1M							3	Bl	38			
									C	35			
									P	24			
									G	3			
Holmes Bay	Shoreline	1	C	77	3	P	44						
			P	21		G	56						
			G	2									
	1M	3	Bl	6				3	Bl	19	3	Br	100
			C	37					C	62			
			P	47					P	18			
			G	10					G	1			

Br - Bedrock Bl - Boulder C - Cobble P - Pebble G - Gravel Sa - Sand Sl - Silt

Appendix 1 con't

MEAN % COMPOSITION													
TRANSECT	DEPTH	1979			1980			1981			1982		
		No Obs.	% Comp.		No. Obs.	% Comp.		No OBs.	% Comp		No OBs.	% Comp.	
Holmes Bay	2M	3	Bl	45									
			C	17									
			P	31									
			G	7									
	3M	3	Br	26	3	C	48						
			C	8		P	48						
			P	4		G	1						
			Sa	62		Sa	3						
	4M	3	C	49									
			P	16									
			G	1									
			Sa	34									
	5M	3	C	41									
			P	5									
			Sl	54									
	6M	3	C	5									
			P	6									
			Sl	89									
	7M	3	C	46	3	Br	100						
			P	3									
			G	1									
			Sl	50									
	8M	3	Bl	3									
			C	58									
			P	9									
			G	3									
			Sl	27									

Br - Bedrock Bl - Boulder C - Cobble P - Pebble G - Gravel Sa - Sand Sl - Silt

Appendix 1 con't

MEAN % COMPOSITION									
TRANSECT	DEPTH	1979		1980		1981		1982	
		No Obs.	% Comp.	No. Obs.	% Comp.	No OBs.	% Comp	No OBs.	% Comp.
Holmes Bay	10M	3	Bl 3 C 73 P 17 G 4 Sl 3						
	11M	3	Bl 16 C 54 P 25 G 4 Sl 1						
	12M	3	C 72 P 27 G 1	3	Bl 15 C 55 P 24 G 6				
Between Holmes Bay and Gunn Pt.	Shoreline				Br 63 C 19 P 17 G 1				
	1M					3	Br 96 C 4		
Gunn Pt.	Shoreline	1	C 40 P 60	3	C 41 P 49 G 10				
	1M	1	Br 100			3	Br 100	3	Br 92 C 3 P 4 G 1

Br - Bedrock Bl - Boulder C - Cobble P - Pebble G - Gravel Sa - Sand Sl - Silt

Appendix 1 con't

MEAN % COMPOSITION									
TRANSECT	DEPTH	1979		1980		1981		1982	
		No Obs.	% Comp.	No. Obs.	% Comp.	No OBs.	% Comp	No OBs.	% Comp.
Gunn Point	2M	1	Br 100						
	3M	3	Br 100	3	Br 100				
	4M	3	Br 70 Bl 7 C 15 P 7 G 1						
	5M	3	Bl 13 C 39 P 23 G 25						
	7M	3	Bl 23 C 47 P 23 G 5 Sa 2	3	Bl 15 C 33 P 48 G 3 Sa 1				
	9M	3	Br 11 Bl 24 C 16 P 16 G 31 Sa 2						
	10M	3	Br 33 Bl 13 C 33 P 16 G 4 Sa 1						

Br - Bedrock Bl - Boulder C - Cobble P - Pebble G - Gravel Sa - Sand Sl - Silt

Appendix 1 con't

MEAN % COMPOSITION												
TRANSECT	DEPTH	1979			1980			1981			1982	
		No Obs.		% Comp.	No. Obs.		% Comp.	No OBs.		% Comp	No OBs.	% Comp.
Gunn Pt.	12M	3	Bl	12	3	Bl	26					
			C	40		C	29					
			P	41		P	43					
			G	7		G	2					
Between Gunn Pt. and Inverhuron Bay	Shoreline				3	C	5					
						P	12					
						G	30					
						Sa	53					
	1M							3	Sa	100		
Inverhuron Bay	Shoreline				3	P	6					
						G	3					
						Sa	91					
	1M							3	Br	99		
									Sa	1		
	3M				3	Br	76					
						C	3					
						P	19					
						G	2					
	7M				3	Br	49					
						Bl	33					
						C	16					
						P	1					
						Sa	1					
	12M				3	Sa	100					

Br - Bedrock Bl - Boulder C - Cobble P - Pebble G - Gravel Sa - Sand Sl - Silt

Appendix 1 con't

MEAN % COMPOSITION									
TRANSECT	DEPTH	1979		1980		1981		1982	
		No Obs.	% Comp.	No. Obs.	% Comp.	No OBs.	% Comp	No OBs.	% Comp.
Between Inverhuron Bay and McRae Pt.	Shoreline			3	Br 47 C 25 P 27 G 1				
	1M					3	Br 41 Bl 10 C 20 P 22 G 6		
McRae Pt.	Shoreline			3	Br 33 Bl 25 C 10 P 28 G 4				
	1M					3	Br 53 Bl 19 C 14 P 14		
	3M			3	Br 47 Bl 30 C 10 P 12 G 1				
	7M			3	Bl 38 C 48 P 9 G 5				

Br - Bedrock Bl - Boulder C - Cobble P - Pebble G - Gravel Sa - Sand Sl - Silt

Appendix 1 con't

MEAN % COMPOSITION								
TRANSECT	DEPTH	1979		1980		1981		1982	
		No Obs.	% Comp.	No. Obs.	% Comp.	No OBs.	% Comp	No OBs.	% Comp.
McRae Pt.	12M			3	Br 8 C 62 P 30				

Br - Bedrock Bl - Boulder C - Cobble P - Pebble G - Gravel Sa - Sand Sl - Silt

Appendix 2

Substrate Composition in Replicate Locations in 1982

(1 of 3 slides selected for each location)

Location		% Contribution of Substrate Categories					
		Bedrock	Boulder	Cobble	Pebble	Gravel	Sand, Silt
Douglas Pt	a	75		10	15		
	b		3	40	45	10	2
	c	80		5	5	5	5
	$\bar{x}$	52	1	18	22	5	2
Lagoon Bay	a	85			15		
	b		47	33	15	5	
	c			75	20	5	
	$\bar{x}$	28	16	36	17	3	
Bruce 'B' Intake	a		47	34	15	4	
	b	100					
	c	81		16			3
	$\bar{x}$	60	16	17	5	1	1
S. Boundary Pt	a		64	23	12	1	
	b		54	42	3	1	
	c		71	26	3		
	$\bar{x}$		63	30	6	1	
Holmes Bay	a	100					
	b	100					
	c	100					
	$\bar{x}$	100					
Gunn Pt	a	92			7	1	
	b	100					
	c	84		10	5	1	
	$\bar{x}$	92		3	4	1	*

* A fine layer of silt overlay the bedrock at this location.

APPENDIX 3

ICHTHYOPLANKTON COLLECTED IN LARVAL TOW NETS
AT 1 M DEPTH AT BRUCE GS 'B', 1982
MEAN DENSITY FOR 2 TOWS AS NO/1000 M^3

Species	Douglas Pt	Lagoon Bay	Br 'B' Disch	Br 'B' Intake	S.Bound. Pt	Holmes Bay	Gunn Pt	Inver-huron B.
	April 29							
Surface Water Temp	11.8°C	6.0°	4.8°	5.0°	5.0°	3.5°	3.8°	4.0°
Rainbow smelt eggs	154	169	42					
	May 14							
Surface Water Temp	5.0	6.5°	6.5°	6.0°	6.0°	6.5°	5.5°	6.5°
Rainbow smelt eggs	14							
Larvae:								
Rainbow smelt	42	351	56		42	14	14	
Burbot		28		56		28	70	140
White sucker	28							
Deepwater sculpin								
	May 19							
Surface Water Temp	12.0°	6.5°	6.0°	7.0°	7.0°	7.0°	7.0°	8.0°
Rainbow Smelt	2697	1601	309	56	98	56	28	
Burbot	140		28	56	42	14	52	42
Deepwater Sculpin	14							
White sucker	28							
	May 27							
Surface Water Temp	6.5°	6.5°	6.5°	6.5°	6.5°	7.5°	6.9°	7.5°
Rainbow Smelt	295	98	674	309	154	42	534	211
Burbot	154	70	169	520	183	56	98	267
Deepwater sculpin	14							
Longnose sucker	14							

Species	Douglas Pt	Lagoon Bay	Br 'B' Disch	Br 'B' Intake	S.Bound. Pt	Holmes Bay	Gunn Pt	Inver-huron B.
	May 5							
Surface Water Temp	8.0°	5.0°	6.5°	6.5°	5.5°	7.0°	7.0°	7.0°
Rainbow smelt eggs	70	14						
	May 18							
Surface Water Temp	8.5°	6.8°	5.5°	8.0°	6.0°	8.0°	7.5°	8.5°
Rainbow smelt eggs						14		
Larvae:								
Rainbow smelt	623	98	196	14	28	703		
Burbot	351	126	98	14	28	197	56	169
White sucker	14							
Deepwater sculpin	42							
	May 26							
Surface Water Temp	8.0°	6.2°	8.0°	6.0°	6.0°	9.0°	7.5°	8.5°
Rainbow Smelt	183	154	1657	3020	716	126	84	12 725
Burbot	154	1138	772	941	295	154	70	3 076
Deepwater Sculpin								14
White sucker	14							

Mean sampling volumes (M^3/tow) by transect

36.0	32.8	36.3	34.7	36.0	36.1	37.6	35.7

Overall mean sampling volume 35.6 M^3/tow

APPENDIX 4

TOTAL LENGTH (mm) OF FISH LARVAE COLLECTED AT BRUCE GS 'B' IN MAY, 1982

Species	Date											
	May 14				May 18-19				May 26-27			
	n	$\bar{x}$	s	Range	n	$\bar{x}$	s	Range	n	$\bar{x}$	s	Range
Rainbow Smelt	36	5.26	0.25	5.0 - 6.0	129	6.07	0.34	5.5 - 7.0	231	6.11	0.35	5.0 - 7.0
Burbot	15	4.03	0.12	4.0 - 4.5	78	3.98	0.31	3.5 - 4.5	202	4.11	0.38	3.5 - 5.5
Deepwater Sculpin									2	15.5	-	15.0 - 16.0
White Sucker	2	13.25	-	13.0 - 13.5	3	12.0	0	12.0				
Longnose Sucker									1	15.0	-	15.0

APPENDIX 5

BRUCE GS 'B' WINTER GILL NET CATCHES, 1982

	Douglas Pt					Bruce 'B' Discharge				
	Jan 28	Jan 29	Feb 9	Feb 10	Total	Jan 28	Jan 29	Feb 9	Feb 10	Total
5 M										
Burbot	1		3		4	2		2	3	7
White sucker			1		1			2	1	3
Longnose sucker			1		1					
Round whitefish			12		12	2		1	3	6
Lake chub										
Gizzard shad								1		1
Spottail shiner										
Rainbow smelt			1		1					
Rainbow trout										
Walleye										
Lamprey										
Total	1	0	18	0	19	4	0	6	7	17
12 M										
Burbot	2		9	7	18	8	1	9	3	21
White sucker	1	2	2		5	1	3	7	6	17
Longnose sucker	1		2	3	6	9		4	1	14
Round whitefish							1		1	2
Lake chub	1				1			1		1
Gizzard shad										
Spottail shiner	1				1			1		1
Yellow perch										
Rainbow smelt										
Rainbow trout										
Walleye										
Lamprey										
Total	6	2	13	10	31	18	5	22	11	56

APPENDIX 5 (Cont'd)

BRUCE GS 'B' WINTER GILL NET CATCHES, 1982

	Bruce 'B' Intake					Holmes Bay				
	Jan 28	Jan 29	Feb 9	Feb 10	Total	Jan 28	Jan 29	Feb 9	Feb 10	Total
5 M										
Burbot		1		1	2	1	1	1	2	5
White sucker	1			2	3			2		2
Longnose sucker										
Round whitefish				1	1	1	1	3	1	6
Lake chub	1		1		2			2	1	3
Gizzard shad			2		2					
Spottail shiner										
Yellow perch										
Rainbow smelt										
Rainbow trout										
Walleye										
Lamprey										
Total	2	1	3	4	10	2	2	8	4	16
12 M										
Burbot	10		7	5	22		2	1	3	6
White sucker	2		3	1	6				2	2
Longnose sucker	4		4		8			2	1	3
Round whitefish								1		1
Lake chub	2	Net Lost			2	1		1		2
Gizzard shad										
Spottail shiner										
Yellow perch	1				1					
Rainbow smelt										
Rainbow trout										
Walleye										
Lamprey	1				1					
Total	20	0	14	6	40	1	2	5	6	14

APPENDIX 5 (Cont'd)

BRUCE GS 'B' WINTER GILL NET CATCHES, 1982

	Gunn Pt					McRae Pt				
	Jan 28	Jan 29	Feb 9	Feb 10	Total	Jan 28	Jan 29	Feb 9	Feb 10	Total
5 M										
Burbot			5	1	6		1	5	1	7
White sucker	1		6		7	3	3	2	5	13
Longnose sucker						1		1	1	3
Round whitefish	1				1					
Lake chub			1		1	2		2		4
Gizzard shad		2		1	3					
Spottail shiner										
Yellow perch										
Rainbow smelt										
Rainbow trout		1			1			1		1
Walleye										
Lamprey										
Total	2	3	12	2	19	6	4	11	7	28
12 M										
Burbot	2		3	1	6	2	1	4	6	13
White sucker	1	2	7	2	12	4	11	7	2	24
Longnose sucker	3		5		8	7		8	1	16
Round whitefish										
Lake chub	1		2		3					
Gizzard shad						2				2
Spottail shiner									1	1
Yellow perch										
Rainbow smelt										
Rainbow trout										
Walleye										
Lamprey										
Total	7	2	17	3	29	15	12	19	10	56

APPENDIX 5 (Cont'd)

BRUCE GS 'B' WINTER GILL NET CATCHES, 1982

	Gunn Pt					McRae Pt				
	Jan 28	Jan 29	Feb 9	Feb 10	Total	Jan 28	Jan 29	Feb 9	Feb 10	Total
5 M										
Burbot			5	1	6		1	5	1	7
White sucker	1		6		7	3	3	2	5	13
Longnose sucker						1		1	1	3
Round whitefish	1				1					
Lake chub			1		1	2		2		4
Gizzard shad		2		1	3					
Spottail shiner										
Yellow perch										
Rainbow smelt										
Rainbow trout		1			1					
Walleye								1		1
Lamprey										
Total	2	3	12	2	19	6	4	11	7	28
12 M										
Burbot	2		3	1	6	2	1	4	6	13
White sucker	1	2	7	2	12	4	11	7	2	24
Longnose sucker	3		5		8	7		8	1	16
Round whitefish										
Lake chub	1		2		3					
Gizzard shad										
Spottail shiner						2				2
Yellow perch									1	1
Rainbow smelt										
Rainbow trout										
Walleye										
Lamprey										
Total	7	2	17	3	29	15	12	19	10	56

APPENDIX 5 (Cont'd)

BRUCE GS 'B' WINTER GILL NET CATCHES, 1982

	Bruce 'B' Intake					Holmes Bay				
	Jan 28	Jan 29	Feb 9	Feb 10	Total	Jan 28	Jan 29	Feb 9	Feb 10	Total
5 M										
Burbot		1		1	2	1	1	1	2	5
White sucker	1			2	3			2		2
Longnose sucker										
Round whitefish				1	1	1	1	3	1	6
Lake chub	1		1		2			2	1	3
Gizzard shad			2		2					
Spottail shiner										
Yellow perch										
Rainbow smelt										
Rainbow trout										
Walleye										
Lamprey										
Total	2	1	3	4	10	2	2	8	4	16
12 M										
Burbot	10		7	5	22		2	1	3	6
White sucker	2		3	1	6				2	2
Longnose sucker	4		4		8			2	1	3
Round whitefish								1		1
Lake chub	2				2	1		1		2
Gizzard shad										
Spottail shiner										
Yellow perch	1				1					
Rainbow smelt										
Rainbow trout										
Walleye										
Lamprey	1				1					
Total	20	0	14	6	40	1	2	5	6	14

Net Lost

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